CLAIMS

We Claim:

1. A method, comprising:

depositing two sacrificial layers on a substrate;

forming an array of mirror plates on one of the two sacrificial layers;

forming a hinge, for each mirror plate, on the other sacrificial layer of the two sacrificial layers, wherein the sacrificial layer between the mirror plate and the hinge is from 0.15 to 0.45 micrometers; and

removing at least a portion of one or both of the two sacrificial layers using a spontaneous vapor phase chemical etchant.

2. The method of claim 1, wherein the array of mirror plates comprises at least 1280 mirror plates along a length of the mirror plate array.

3. The method of claim 1, wherein the array of mirror plates comprises at least 1400 mirror plates along a length of the mirror plate array.

4. The method of claim 1, wherein the array of mirror plates comprises at least 1600 mirror plates along a length of the mirror plate array.

5. The method of claim 1, wherein the array of mirror plates comprises at least 1920 mirror plates along a length of the mirror plate array.

6. The method of claim 1, wherein the step of removing the two sacrificial layers using the spontaneous vapor phase etchant further comprises:

removing the sacrificial layer between the substrate and the mirror plates via a gap between adjacent mirror plates.

7. The method of claim 6, wherein the gap is 0.45 micrometers or less.

8. The method of claim 6, wherein the gap is from 0.15 to 0.25 micrometers.

9. The method of claim 1, wherein the gap is from 0.25 to 0.5 micrometers.

10. The method of claim 1, wherein the step of forming the array of mirror plates on one of the two sacrificial layers, further comprising:

forming the array of mirror plates such that a center-to-center distance between the adjacent mirror plates is from 4.38 to 10.16 micrometers.

11. The method of claim 1, wherein the step of forming the array of mirror plates on one of the two sacrificial layers, further comprising:

forming the array of mirror plates such that a center-to-center distance between the adjacent mirror plates is from 8.07 to 10.16 micrometers.

12. The method of claim 1, wherein the step of forming the array of mirror plates on one of the two sacrificial layers, further comprising:

forming the array of mirror plates such that a center-to-center distance between the adjacent mirror plates is from 6.23 to 9.34 micrometers.

13. The method of claim 1, wherein the step of forming the array of mirror plates on one of the two sacrificial layers, further comprising:

forming the array of mirror plates such that a center-to-center distance between the adjacent mirror plates is from 4.38 to 6.57 micrometers.

14. The method of claim 1, wherein the step of forming the array of mirror plates on one of the two sacrificial layers, further comprising:

forming the array of mirror plates such that a center-to-center distance between the adjacent mirror plates is from 4.38 to 9.34 micrometers.

15. The method of claim 1, wherein the step of forming the hinge on the other sacrificial layer for each mirror plate further comprises:

forming the hinge for the mirror plate such that, after removing the sacrificial layers, a) the mirror plate can rotate relative to the substrate along a rotation axis that is parallel to

but offset from a diagonal of the mirror plate when viewed from the top of the mirror plate; and b) the mirror plate can rotate to an angle at least 14 degrees relative to the substrate; and

wherein the step of forming the array of mirror plates on the sacrificial layer further comprises:

forming the array of mirror plates on the sacrificial layer such that adjacent mirror plates have a center-to-center distance from 4.38 to 10.16 micrometers.

16. The method of claim 1, wherein the step of forming the hinge on the sacrificial layer for each mirror plate further comprises:

forming the hinge such that, after removing the two sacrificial layers, the mirror plate can rotate to a rotation angle at least 14 degrees relative to the substrate.

17. The method of claim 1, further comprising:

forming an electrode for each mirror plate; and

disposing the electrode proximate to the mirror plate for electrostatically deflecting the mirror plate.

18. The method of claim 1, wherein the substrate is glass or quartz that is visible light transmissive.

19. The method of claim 18, further comprising:

depositing an anti-reflection film on a surface of the substrate.

20. The method of claim 18, further comprising:

depositing a light absorbing frame around an edge of the substrate.

21. The method of claim 1, wherein the step of removing the sacrificial layers further comprises:

monitoring an endpoint of the sacrificial layer being removed using a residual gas analyzer.

22. The method of claim 1, wherein one or both of the sacrificial layers are amorphous silicon.

23. The method of claim 1, wherein the spontaneous vapor phase chemical etchant is an interhalogen.

24. The method of claim 1, wherein the spontaneous vapor phase chemical etchant is a noble gas halide.

25. The method of claim 24, wherein the noble gas halide comprises xenon difluoride.

26. The method of claim 23, wherein the interhalogen comprises bromine trichloride or bromine trifluoride.

27. The method of claim 1, wherein a diluent is mixed with the spontaneous vapor phase chemical etchant.

28. The method of claim 27, wherein the diluent is selected from N_2, He, Ar, Kr and Xe.

29. The method of claim 27, wherein the diluent is selected from N_2 and He.

30. The method of claim 1, wherein each mirror plate has an area; and wherein a ratio of a summation of all areas of the mirror plates to an area of the substrate is 90 percent or more.

31. The method of claim 1, wherein each mirror plate rotates relative to the substrate in response to an electrostatic force.

32. The method of claim 1, further comprising:

disposing a first electrode proximate to each mirror plate for driving the mirror plate to rotate in a first rotational direction relative to the substrate; and

disposing a second electrode proximate to said mirror plate for driving the mirror plate to rotate in a second rotational direction opposite to the first rotational direction.

33. The method of claim 32, wherein the first and second electrode is disposed on the same side relative to the rotation axis of the mirror plate.

34. The method of claim 32, wherein the first electrode and the second electrode are disposed on opposite sides relative to the rotation axis of the mirror plate.

35. The method of claim 1, wherein the substrate is semiconductor.

36. The method of claim 1, wherein the array of mirror plates are formed on a sacrificial layer that is deposited on the substrate; and wherein the hinge is formed on the sacrificial layer that is deposited on the formed mirror plates.

37. The method of claim 1, wherein the step of forming the hinge further comprises:

forming the hinge such that, after removing the two sacrificial layers, the mirror plate is attached to the hinge and the mirror plate can rotate in a first direction to an angle from 15° degrees to 27° degrees relative to the substrate.

38. The method of claim 37, wherein the step of forming the hinge further comprises:

forming the hinge such that, after removing the two sacrificial layers, the mirror plate is attached to the hinge and the mirror plate can rotate in a second direction opposite to the first direction to another angle from -2° degrees to -9° degrees relative to the substrate.

39. The method of claim 1, wherein the step of forming the hinge further comprises:

forming the hinge such that, after removing the two sacrificial layers, the mirror plate is attached to the hinge and the mirror plate can rotate in a first direction to an angle from 17.5° degrees to 22.5° degrees relative to the substrate.

40. The method of claim 39, wherein the step of forming the hinge further comprises:

forming the hinge such that, after removing the two sacrificial layers, the mirror plate is attached to the hinge and the mirror plate can rotate in a second direction opposite to the first direction to another angle from -2° degrees to -9° degrees relative to the substrate.

41. The method of claim 1, wherein the step of forming the hinge further comprises:

forming the hinge such that, after removing the two sacrificial layers, the mirror plate is attached to the hinge and the mirror plate can rotate in a first direction to an angle around 20^{o} degrees relative to the substrate.

42. The method of claim 41, wherein the step of forming the hinge further comprises:

forming the hinge such that, after removing the two sacrificial layers, the mirror plate is attached to the hinge and the mirror plate can rotate in a second direction opposite to the first direction to another angle from -2^{o} degrees to -9^{o} degrees relative to the substrate.

43. The method of claim 1, wherein the step of forming the hinge further comprises:

forming the hinge such that, after removing the two sacrificial layers, the mirror plate is attached to the hinge and the mirror plate can rotate in a first direction to an angle around 30^{o} degrees relative to the substrate.

44. The method of claim 43, wherein the step of forming the hinge further comprises:

forming the hinge such that, after removing the two sacrificial layers, the mirror plate is attached to the hinge and the mirror plate can rotate in a second direction opposite to the first direction to another angle from -2^{o} degrees to -9^{o} degrees relative to the substrate.

45. The method of claim 10, further comprising:

forming the hinge such that, after removing the two sacrificial layers, the mirror plate is attached to the hinge and the mirror plate can rotate in a first direction to an angle from 12^{o} degrees to 20^{o} degrees relative to the substrate.

46. The method of claim 45, further comprising:

forming the hinge such that, after removing the two sacrificial layers, the mirror plate is attached to the hinge and the mirror plate can rotate in a second direction opposite to the first direction to another angle from -2^{o} degrees to -9^{o} degrees relative to the substrate.

47. The method of claim 8, further comprising:

forming the hinge such that, after removing the two sacrificial layers, the mirror plate is attached to the hinge and the mirror plate can rotate in a first direction to an angle from 12° degrees to 20° degrees relative to the substrate.

48. The method of claim 47, further comprising:

forming the hinge such that, after removing the two sacrificial layers, the mirror plate is attached to the hinge and the mirror plate can rotate in a second direction opposite to the first direction to another angle from -2° degrees to -9° degrees relative to the substrate.

49. The method of claim 8, wherein the center-to-center distance between adjacent mirror plates is from 4.38 to 10.16 micrometers.

50. The method of claim 47, wherein the center-to-center distance between adjacent mirror plates is from 4.38 to 10.16 micrometers.

51. A spatial light modulator, comprising: an array of movable mirror plates, each mirror plate being attached to a hinge that is supported by a hinge structure such that the mirror plate can rotate relative to a substrate, on which the hinge structure is formed; and wherein the hinge and the mirror plate is spaced apart from 0.5 to 1.5 micrometers.

52. The spatial light modulator of claim 51, wherein the adjacent mirror plates of the array of mirror plates have a center-to-center distance from 4.28 to 10.16 micrometers.

53. The spatial light modulator of claim 51, wherein the adjacent mirror plates of the array of mirror plates have a gap from 0.15 to 0.25 micrometers when the adjacent mirror plates are parallel to the substrate.

54. The spatial light modulator of claim 51, wherein the adjacent mirror plates have a gap from 0.25 to 0.45 micrometers.

55. The spatial light modulator of claim 51, wherein the adjacent mirror plates of the array of mirror plates have a gap of 0.45 micrometers or less when the adjacent mirror plates are parallel to the substrate.

56. The spatial light modulator of claim 51, wherein the array of mirror plates comprises at least 1280 mirror plates along a length of the mirror plate array.

57. The spatial light modulator of claim 51, wherein the array of mirror plates comprises at least 1400 mirror plates along a length of the mirror plate array.

58. The spatial light modulator of claim 51, wherein the array of mirror plates comprises at least 1600 mirror plates along a length of the mirror plate array.

59. The spatial light modulator of claim 51, wherein the array of mirror plates comprises at least 1920 mirror plates along a length of the mirror plate array.

60. The spatial light modulator of claim 51, wherein the hinge and the mirror plate is spaced apart from 0.5 to 0.8 micrometers.

61. The spatial light modulator of claim 51, wherein the hinge and the mirror plate is spaced apart from 0.8 to 1.25 micrometers.

62. The spatial light modulator of claim 51, wherein the hinge and the mirror plate is spaced apart from 1.25 to 1.5 micrometers.

63. The spatial light modulator of claim 52, wherein the center-to-center distance of adjacent mirror plates is from 6.23 to 9.34 micrometers.

64. The spatial light modulator of claim 52, wherein the center-to-center distance of adjacent mirror plates is from 4.38 to 6.57 micrometers.

65. The spatial light modulator of claim 52, wherein the center-to-center distance of adjacent mirror plates is from 4.38 to 9.34 micrometers.

66. The spatial light modulator of claim 51, wherein the hinge is attached to the mirror plate such that the mirror plate can rotate relative to the substrate along a rotation axis that is parallel to but offset from a diagonal of the mirror plate when viewed from the top of the mirror plate; wherein the mirror plate can rotate to an angle at least 14 degrees relative to the substrate; and wherein the adjacent mirror plates has a center-to-center distance from 4.38 to 10.16 micrometers; and wherein the hinge and the mirror plate is spaced apart from 0.5 to 1.5 micrometers.

67. The spatial light modulator of claim 51, further comprising:

an electrode proximate to each mirror plate for electrostatically deflecting the mirror plate.

68. The spatial light modulator of claim 51, wherein the substrate is glass or quartz that is visible light transmissive.

69. The spatial light modulator of claim 68, wherein the substrate comprises an anti-reflection film on a surface of the substrate.

70. The spatial light modulator of claim 68, wherein the substrate comprises a light absorption frame around an edge of the substrate.

71. The spatial light modulator of claim 51, wherein each mirror plate has an area; and wherein a ratio of a summation of all areas of the mirror plates to an area of the substrate is 90 percent or more.

72. The spatial light modulator of claim 51, wherein each mirror plate rotate relative to the substrate in response to an electrostatic field.

73. The spatial light modulator of claim 51, further comprising:

a first electrode that drives the mirror plate rotate in a first rotation direction relative to the substrate; and

a second electrode that drives the mirror plate rotate in a second rotation direction opposite to the first rotation direction relative to the substrate.

74. The spatial light modulator of claim 73, wherein the first electrode and the second electrode are on the same side relative to the rotation axis of the mirror plate.

75. The spatial light modulator of claim 73, wherein the first electrode and the second electrode are on the opposite sides relative to the rotation axis of the mirror plate.

76. The spatial light modulator of claim 51, wherein the substrate is semiconductor.

77. The spatial light modulator of claim 51, wherein the mirror plate is attached to the hinge such that the mirror plate rotates in a first direction to an angle from 15° degrees to 27° degrees relative to the substrate.

78. The spatial light modulator of claim 77, wherein the mirror plate is attached to the hinge such that the mirror plate rotates in a second direction to an angle from 2° degrees to 9° degrees relative to the substrate.

79. The spatial light modulator of claim 51, wherein the mirror plate is attached to the hinge such that the mirror plate rotates in a first direction to an angle from 17.5° degrees to 22.5° degrees relative to the substrate.

80. The spatial light modulator of claim 79, wherein the mirror plate is attached to the hinge such that the mirror plate rotates in a second direction to an angle from 2° degrees to 9° degrees relative to the substrate.

81. The spatial light modulator of claim 51, wherein the mirror plate is attached to the hinge such that the mirror plate rotates in a first direction to an angle around 20° degrees relative to the substrate.

82. The spatial light modulator of claim 81, wherein the mirror plate is attached to the hinge such that the mirror plate rotates in a second direction to an angle from 2° degrees to 9° degrees relative to the substrate.

83. The spatial light modulator of claim 51, wherein the mirror plate is attached to the hinge such that the mirror plate rotates in a first direction to an angle around 30° degrees relative to the substrate.

84. The spatial light modulator of claim 83, wherein the mirror plate is attached to the hinge such that the mirror plate rotates in a second direction to an angle from 2° degrees to 9° degrees relative to the substrate.

85. The spatial light modulator of claim 53, wherein a center-to-center distance between adjacent mirror plates is from 4.38 to 10.16 micrometers.

86. The spatial light modulator of claim 52, wherein the mirror plate is attached to the hinge such that the mirror plate rotates in a first direction to an angle from 12° degrees to 20° degrees relative to the substrate.

87. The spatial light modulator of claim 86, wherein the mirror plate is attached to the hinge such that the mirror plate rotates in a second direction to an angle from 2° degrees to 9° degrees relative to the substrate.

88. The spatial light modulator of claim 85, wherein the mirror plate is attached to the hinge such that the mirror plate rotates in a first direction to an angle from 12° degrees to 20° degrees relative to the substrate.

89. The spatial light modulator of claim 88, wherein the mirror plate is attached to the hinge such that the mirror plate rotates in a second direction to an angle from 2° degrees to 9° degrees relative to the substrate.

90. A projection system, comprising:

a light source;

a spatial light modulator that further comprises:

an array of mirror devices formed on a substrate for selectively reflecting light incident on the mirror devices, wherein each mirror device comprises:

a mirror plate for reflecting light;

a hinge attached to the mirror plate such that the mirror plate can rotate relative to the substrate, wherein the hinge and the mirror plate are spaced apart from 0.5 to 1.5 micrometers; and

a hinge support on the substrate for holding the hinge on the substrate;

a condensing lens for directing light from the light source onto the spatial light modulator; and

a projecting lens for collecting and directing light reflected from the spatial light modulator onto a display target.

91. The system of claim 90, wherein the array of mirror devices comprises at least 1280 mirror devices along a length of the array.

92. The system of claim 90, wherein the array of mirror devices comprises at least 1400 mirror devices along a length of the array.

93. The system of claim 90, wherein the array of mirror devices comprises at least 1600 mirror devices along a length of the array.

94. The system of claim 90, wherein the array of mirror devices comprises at least 1920 mirror devices along a length of the array.

95. The system of claim 90, wherein adjacent mirror plates of the mirror plate array have a gap from 0.15 to 0.25 micrometers therebetween when the mirror plates are parallel to the substrate.

96. The system of claim 90, wherein adjacent mirror plates of the mirror plate array have a gap from 0.25 to 0.5 micrometers therebetween when the mirror plates are parallel to the substrate.

97. The system of claim 90, wherein adjacent mirror plates of the mirror plate array have a gap is 0.5 micrometers or less therebetween when the mirror plates are parallel to the substrate.

98. The system of claim 90, wherein adjacent mirror plates of the mirror plate array have a center-to-center distance from 4.38 to 10.16 micrometers therebetween when the mirror plates are parallel to the substrate.

99. The system of claim 90, wherein adjacent mirror plates of the mirror plate array have a center-to-center distance from 8.07 to 10.16 micrometers when the adjacent mirror plates are parallel to the substrate.

100. The system of claim 90, wherein adjacent mirror plates of the mirror plate array have a center-to-center distance from 6.23 to 9.34 micrometers when the adjacent mirror plates are parallel to the substrate.

101. The system of claim 90, wherein adjacent mirror plates of the mirror plate array have a center-to-center distance from 4.38 to 6.57 micrometers when the adjacent mirror plates are parallel to the substrate.

102. The system of claim 90, wherein adjacent mirror plates of the mirror plate array have a center-to-center distance from 4.38 to 9.34 micrometers when the adjacent mirror plates are parallel to the substrate.

103. The system of claim 90, wherein the mirror plate is attached to the hinge such that the mirror plate can rotate relative to the substrate along a rotation axis that is parallel to but offset from a diagonal of the mirror plate when viewed from the top of the mirror plate; and wherein the mirror plate can rotate to an angle at least 14 degrees relative to the substrate;

wherein the adjacent mirror plates have a center-to-center distance from 4.38 to 10.16 micrometers therebetween when the mirror plates are parallel to the substrate; and wherein adjacent mirror plates have a gap therebetween from 0.15 to 0.5 micrometers when the adjacent mirror plates are parallel to the substrate.

104. The system of claim 90, further comprising:

an electrode proximate to each mirror plate for electrostatically deflecting the mirror plate.

105. The system of claim 90, wherein the substrate is glass or quartz that is visible light transmissive.

106. The system of claim 105, wherein the substrate has an anti-reflection film on a surface of the substrate.

107. The system of claim 105, wherein the substrate comprises a light absorbing frame around an edge of the substrate.

108. The system of claim 90, wherein a ratio of a summation of all areas of all mirror plates to an area of the substrate is 90 percent or more.

109. The system of claim 90, wherein the mirror plate of each mirror device rotates relative the substrate in response to an electrostatic field.

110. The system of claim 90, wherein each mirror device further comprises:

a first electrode and circuitry that drives the mirror plate of said mirror device in a first rotational direction; and

a second electrode and circuitry that drives said mirror plate in a second rotational direction opposite to the first rotational direction.

111. The system of claim 110, wherein the first electrode and the second electrode are on the same side relative to the rotation axis of the mirror plate.

112. The system of claim 110, wherein the first electrode and second electrode are on opposite sides relative to the rotation axis of the mirror plate.

113. The system of claim 90, wherein the substrate is semiconductor.

114. The system of claim 90, wherein the light source is an arc lamp having an effective arc length around 1.0 millimeter.

115. The system of claim 90, wherein the light source is an arc lamp having an effective arc length less than 1.0 millimeter.

116. The system of claim 90, wherein the light source is an arc lamp having an effective arc length around 0.7 millimeter.

117. The system of claim 90, further comprising:

a video signal input that inputs a plurality of video signals, based on which the mirror plates of the spatial light modulator selectively reflects light such that the reflected light from the mirror plates forms a plurality of consecutive video frames on the display target.

118. The system of claim 90, wherein the mirror plate is attached to the hinge such that the mirror plate rotates in a first direction to an angle from 15° degrees to 27° degrees relative to the substrate.

119. The system of claim 118, wherein the mirror plate is attached to the hinge such that the mirror plate rotates to in a second direction opposite to the first direction to an angle from 2° degrees to 9° degrees relative to the substrate.

120. The system of claim 90, wherein the mirror plate is attached to the hinge such that the mirror plate rotates in a first direction to an angle from 17.5° degrees to 22.5° degrees relative to the substrate.

121. The system of claim 120, wherein the mirror plate is attached to the hinge such that the mirror plate rotates to in a second direction opposite to the first direction to an angle from 2° degrees to 9° degrees relative to the substrate.

122. The system of claim 90, wherein the mirror plate is attached to the hinge such that the mirror plate rotates in a first direction to an angle around 20° degrees relative to the substrate.

123. The system of claim 122, wherein the mirror plate is attached to the hinge such that the mirror plate rotates to in a second direction opposite to the first direction to an angle from 2° degrees to 9° degrees relative to the substrate.

124. The system of claim 90, wherein the mirror plate is attached to the hinge such that the mirror plate rotates in a first direction to an angle around 20° degrees relative to the substrate.

125. The system of claim 124, wherein the mirror plate is attached to the hinge such that the mirror plate rotates to in a second direction opposite to the first direction to an angle from 2° degrees to 9° degrees relative to the substrate.

126. The system of claim 90, wherein the mirror plate is attached to the hinge such that the mirror plate rotates in a first direction to an angle around 30° degrees relative to the substrate.

127. The system of claim 126, wherein the mirror plate is attached to the hinge such that the mirror plate rotates to in a second direction opposite to the first direction to an angle from 2° degrees to 9° degrees relative to the substrate.